

Space Weather Technical Forecast

Issued on Saturday, 04 February 2023 at 12:43 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: Chance of G1 peaking into the new week. Probable increase in X-ray flare activity through period from arriving regions.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the past 24 hours, with X-ray activity at GOES16 and 17 limited to occasional minor C-class flares in the past 24 hours. These flares peaked in magnitude with a C2.9 observed at 03/1646UTC from sunspot region AR3207 in the southeastern quadrant, which finished the reporting period as a diffuse Cri/Beta. This was one of up to five sunspot regions on the disc, as AR3208 and AR3206 both faded to plage in the 24 hours. These departures were potentially offset by a developing region in the northwest (an Axx/Alpha), and also a newly-numbered bipolar region in the southwest: AR3211, a Bxo/Beta. All the surviving bipolar spots on the disc showed slow proliferating and spreading tendencies, but were otherwise unremarkable.

Although not registering as the peak flare of the period, also of note was a long-period C2.2 seen from the southeastern quadrant at 04/0053UTC, with this associated with a filament lift off that is now likely becoming visible in coronagraphs as mainly orientated east of the Sun-Earth line. Another possible event of note was a filament channel-like signature on e.g. AIA304 in the northwest through the early hours (UTC) of Saturday 04 February, with this also apparently materialising on Lasco.

Coronagraph imagery is currently congested with many apparently peripheral emissions and is being pored through for those that may be Earth-directed, although there are no obvious candidates. At present then, tentatively there are no Earth-directed CMEs confirmed in available imagery.

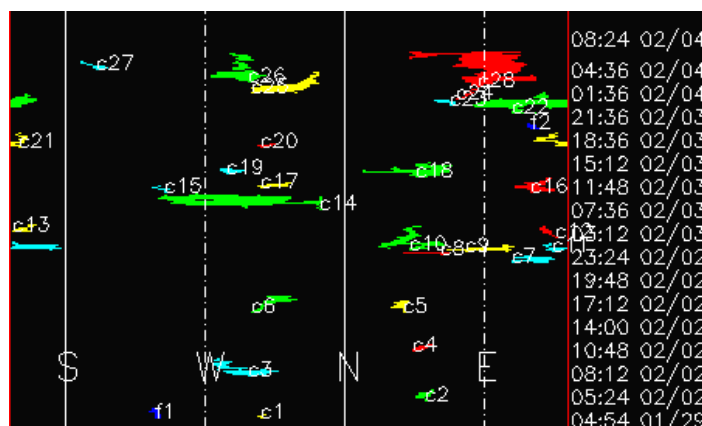


Figure 0: a visual representation (SIDC ROB's CACTus) of the numerous CME candidates presenting in coronagraph imagery in recent hours from all aspects of the disc (time axis is vertical, position of flows and CMEs horizontal). None are confirmed as Earth-directed at the time of writing.

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Solar Wind / Geomagnetic Activity: Solar wind parameters, as observed by DSCOVR and ACE at L1, were indicative of an overall slow regime, but with probable influence from a weak CME onset prior to this 24-hour window, from 03/1050UTC. There was also a minor discontinuity evident in many measures at 03/1800UTC at L1. This discontinuity was near-concurrent at STEREO A (seen at 03/2000UTC), which is located around a day upwind in the Parker spiral. This perhaps implies that this jump was also transient related, albeit not impactful in terms of geomagnetism, and in any case perhaps related to the earlier arrival (i.e. not a novel feature).

Solar wind speeds were within normal Background range in spite of possible CME influence, falling from 375 to near 300km/s by the period's end. The solar wind density was mostly within its typical range, with a slight decline seen from around 10ppcc to single figures with time. The IMF was Slightly Elevated, peaking at 11nT prior to a lowering with the 03/1800UTC discontinuity, while the north-south component varied approximately sinusoidally between +/- 8nT. The phi angle was mostly negative (towards the Sun), but with some time spent in positive territory between 20-22UTC and again from 07-10UTC.

The net effect of the above solar wind measures was for Quiet to Unsettled geomagnetic activity, with a provisional peak Kp of '3+' recorded in the 15-18UTC interval.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES16 remained at Background levels throughout.

High energy electron flux (greater than 2MeV) measured by GOES16 was predominantly at Normal Background levels. The associated 24-hour electron fluence increased slightly and then levelled off through the period, with the plateau reached being near the 2.20e6 integrated pfu observed at 04/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Mainly Low solar activity is expected at first, however there are signs that the arriving eastern limb contains more potent active regions (from CME evidence, prominences and STEREO A EUVI 195 imagery), with a probable increase in activity therefore mooted for the coming UTC working week. This being said, until any regions show, the current Slight Chance of M-class activity is held constant given the largely quiet current Earth-facing side.

Solar Wind / Geomagnetic Activity: No CMEs feature in the forecast at present, however note that there are some (most likely peripheral) unassessed events at the time of writing.

A slow regime and quiet conditions should predominate at first. Uncertainty surrounding the arrival (and now polarity) of the fast wind from CH74/? leads to reduced confidence for much of the remainder of the period, although STEREO A implies any fast wind is at least a day away. Elevated wind speeds are most likely from this feature, with arrival possible from later Day 2 (Sunday 05 February).

Geomagnetic activity is expected to be mainly Quiet at first, but with a Chance of a G1/Minor Storm interval from later day 2 (Sunday 05 February) and possibly Day 3 as the anticipated fast wind arrives.

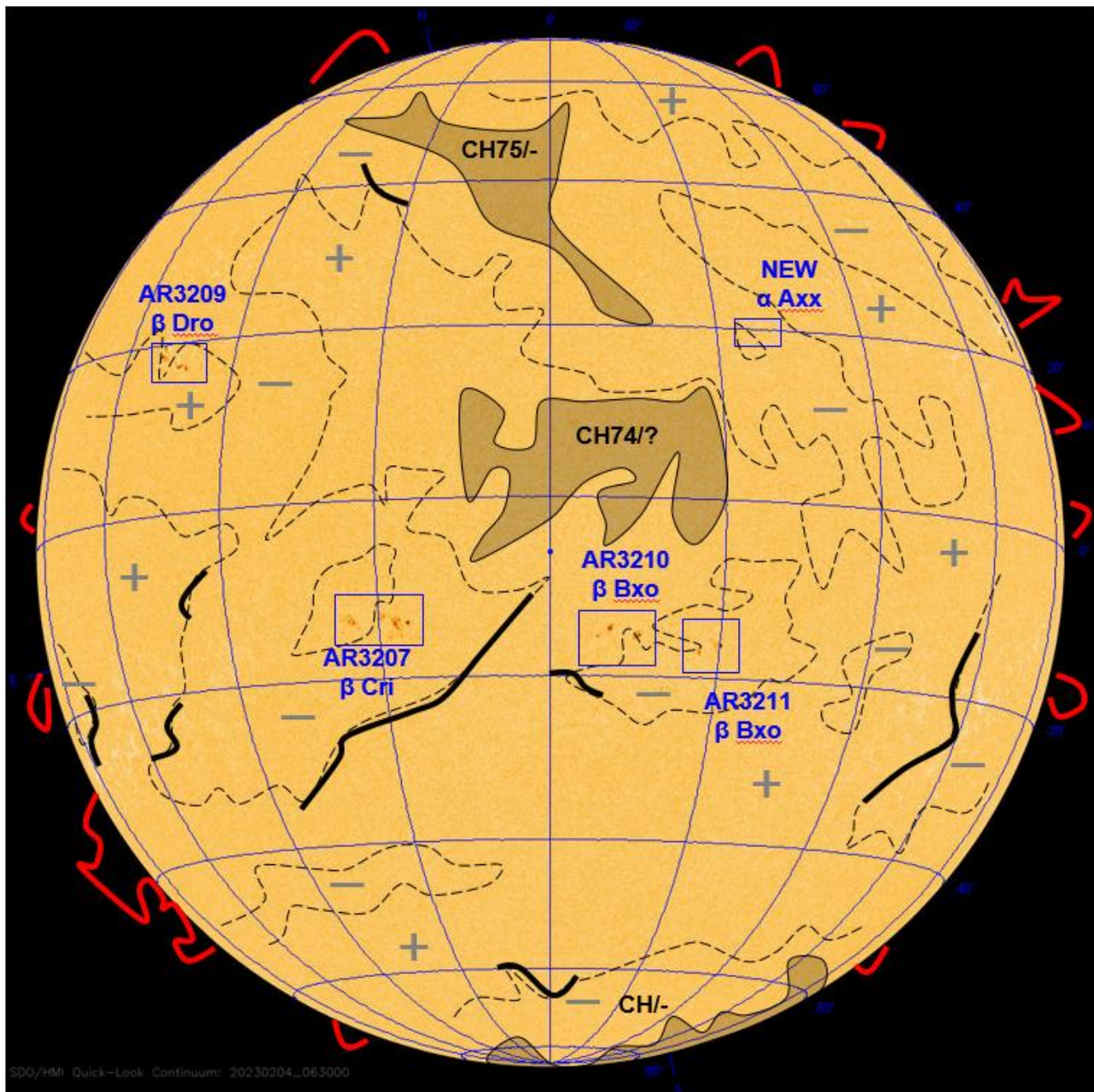
Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux observed by GOES16 is expected to remain at Background levels throughout given the dearth of current sunspot groups.

Electron flux is expected to remain largely at Background to Moderate levels. Electron fluence is expected to remain below the Active (1e8 integrated pfu) threshold. Any increase in electron

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populations is most likely at the very end of the forecast period in the wake of the peak of any fast wind.

Figure 1. Solar Analysis Valid 04/0630UTC.



Key: Filament ___, Prominence ___, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α - β - γ - δ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

As discussed in the solar activity section, Earth is thought to be departing the influence of a CME for a slow wind regime, with the CME perhaps being that from 30 January. This is thought to have been ongoing since 03/1050UTC, with a possible second contribution from 03/1800UTC, evidenced by a similar STEREO A kick at 03/2000UTC. This is the only transient in the forecast at present, however note that there are some (most likely peripheral) CMEs awaiting assessment for lack of imagery.

The geomagnetic forecast therefore comprises one anticipated coronal hole high speed stream, that from non-persistent CH74, and it is therefore of greater than average uncertainty. CH74 has been analysed in recent guidance as a negative polarity hole, however this seems to be less clear-cut now it is crossing the meridian, as it occupies a large and magnetically diffuse region on HMIBC imagery, as well as having an ambiguous extent in AIA193 and 211. Should it be a negative coronal hole, this would be relatively more impactful as we near the vernal equinox.

Of greater confidence is the fact that there does not seem to be any evidence of any fast wind regime in available STEREO A MAG and PLASTIC data, which implies that any fast wind feature is at least a day away from affecting Earth. This would put any G1 effects at the end of Day 2 at the earliest, but probably continuing into the following 24-hour period (i.e. Monday) as the winds peak.

MOSWOC Enlil is currently significantly wayward in its forecasting a fast wind of 600-650km/s as being incipient at Earth through the current UTC day, and is therefore at least 24-36 hours ahead of any fast wind arrival given available STEREO A evidence.

All considered, a peak Chance of G1 is suggested through the end of the UTC weekend and into the very start of the working week, albeit with greater than average uncertainty. The initial 24 hours should be the most reliably Quiet, with a probable tendency to begin revert to these levels at the end of the four days.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	1	20	25	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Nil confirmed, lower than average confidence.

Figure 2: Time-integrated AIA 211 imagery of two noteworthy events in the past 24 hours: firstly (left) a long-period C2.9 flare and filament eruption was observed from the southeast quadrant around 04/0100UTC. Secondly, right, a filament channel-like footprint was seen in the wake of activity in the

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northwest of the Sun around 04/0600UTC. Both of these events appear to be associated with CMEs, with these undergoing analysis at present.

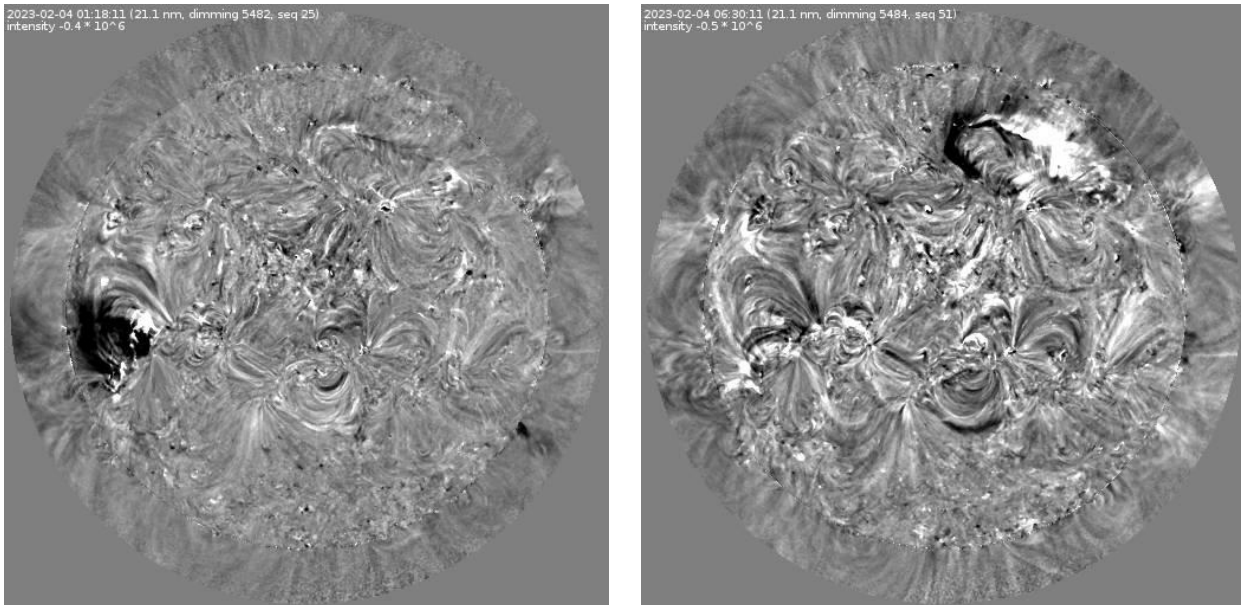
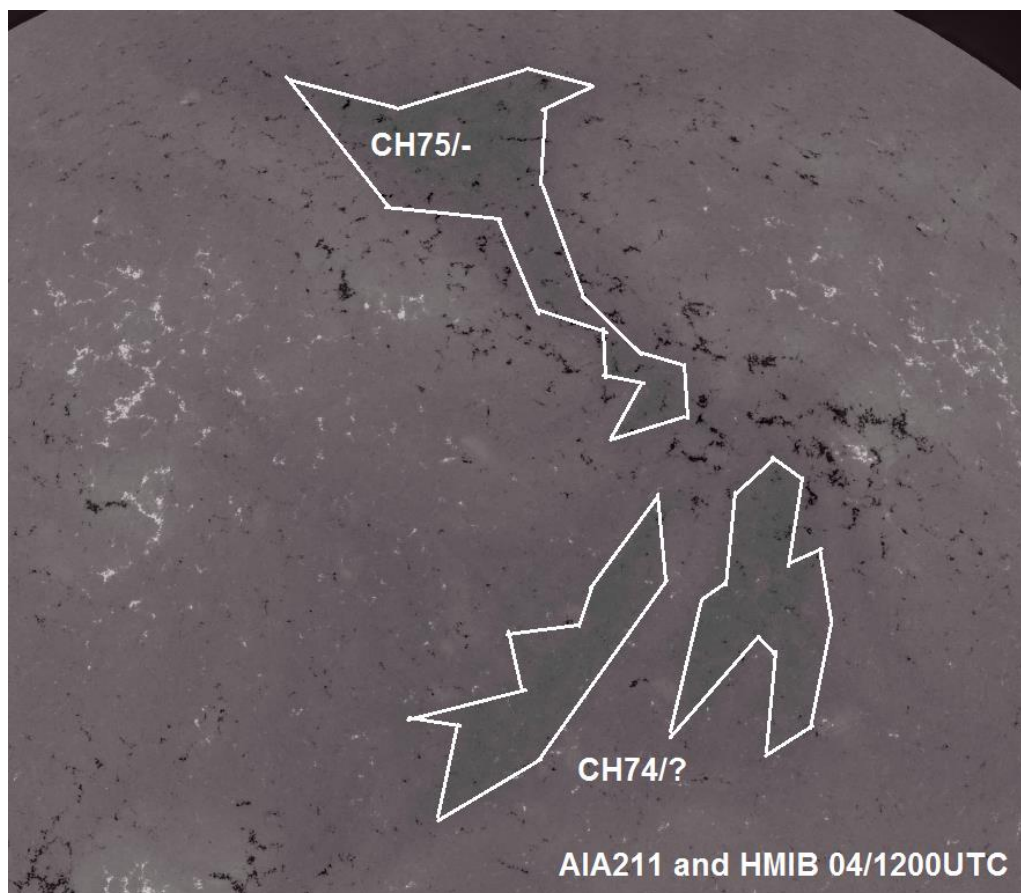


Figure 3: Helioviewer.org-generated composite image from 04/1200UTC showing HMIB and AIA211. CH75/- can be seen to definitively be a negative polarity feature (black in HMIB) , however CH74/- is much less clear, with a knock-on uncertainty as to its potency in the forecast.



Radio Blackouts - X-Ray Flares:

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The current solar disc is the preserve of relatively few and simple bipolar sunspot groups, with two recently fading to plage, and Low solar activity is therefore most likely initially.

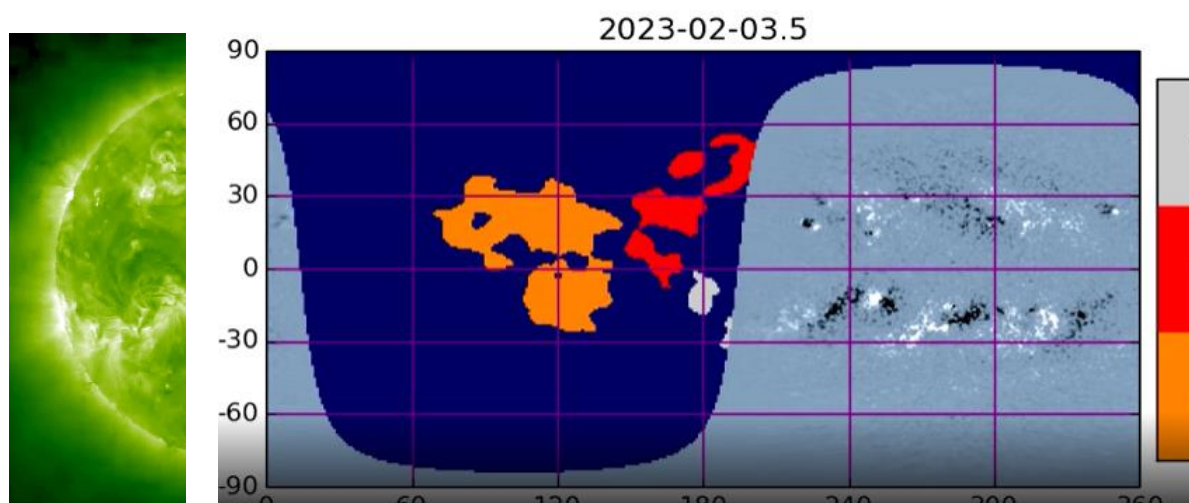
Of potentially greater interest is the possible arrival of numerous Carrington locations for spot groups over the eastern limb in the four days: in numerical order Ex-AR3286; 3288; 3290; 3291; 3292; 3294 and 3295 are all due.

Adding to the evidence is STEREO A EUVI195 imagery, which suggests a southern solar hemisphere bright flux region (perhaps newly-developed), as well as far-side helioseismography, which shows an eastern hemisphere bias of signals from the far side, implying the next week's arrivals will probably be more significant than the week after (mid-month).

The final piece of evidence of an impending busier far side is the presence of a large northeastern solar limb prominence and some recent limb-based CME activity from this area. All the above is borne in mind, however the current far side and directly observable sunspot groups are relatively quiet and unremarkable, resulting in a current daily Slight Chance of M-class flares, with this risk held throughout with a view to react upwards into the coming week.

X Flares	Ray	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability				(%)	(%)	(%)	(%)
Active		R1-R2 M Class	No	10	10	10	10
Very Active		R3 to R5 X Class	No	1	1	1	1

Figure 3: STEREO A EUVI195 imagery (left) showing the imminent eastern limb as of 04/1145UTC, as well as a far-side helioseismograph (right) showing possible upcoming regions on the far-sided eastern solar hemisphere.



Solar Radiation Storms - (High Energy Protons):

High energy (greater than 10MeV) proton flux as observed by GOES16 is at Background levels, and is currently expected to remain as such throughout the period given the dearth of significant sunspot groups at present.

Radiation Storms	Level (cm ⁻² sr ⁻¹ s ⁻¹)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	No	1	1	1	1
Very Active	≥ S3 *	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = cm⁻²sr⁻¹s⁻¹)

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) as observed by GOES16 is currently at mostly Normal Background levels, and is expected to remain so in the near-term due to the lack of suitable external influence.

Beyond the current UTC weekend, MOSWOC REFM is rendered less useful for this forecast period given the initial vestigial CME influence and then the reliance of the forecast on a non-persistent fast wind, where even the polarity of the driving feature now appears less clear-cut. Overall, uncertainty in the geomagnetic forecast carries over into the electron outlook, with the chances of exceeding Active 24-hour fluence greatest at the very end of the coming four days in the possible wake of the peak of the anticipated fast wind.

GEO Electron Environment	Level (cm ⁻² sr ⁻¹ day ⁻¹)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1x10 ⁸	No	1	5	10	30
Very Active	≥ 2 MeV ≥ 1x10 ⁹	No	1	1	1	1